MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2018/2019

EME4086 – FINITE ELEMENT METHOD

(ME)

26 OCTOBER 2018
9.00 a.m. - 11.00 a.m.
(2 Hours, Open Book)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 4 pages with 4 Questions only.
2. Attempt **ALL FOUR** questions of 25 marks each.
3. Please write all your answers in the Answer Booklet provided.

Question 1

An insulation system around a cylindrical pipe consists of two different layers. The first layer immediately on the outer surface of the pipe is made of glass wool and the second one is constructed using plaster of Paris. The cylinder diameter is 0.1m and each insulating layer is 0.01m thick. The thermal conductivity of the glass wool is 0.04 W/m°C and that of the plaster is 0.06 W/m°C. The cylinder carries hot oil at a temperature of 92°C, and the atmospheric temperature outside is 15°C. The heat transfer coefficient from the outer surface of the insulation to the atmosphere is 15 W/m^2°C.

a. Make a sketch of the problem by using minimum number of first order 1-dimensional finite elements. Show node numbers, element numbers and label the materials clearly in the sketch.

[3 marks]

b. Indicate the boundary conditions by using appropriate equations.

[2 marks]

c. Provide global matrices for the problem in the form of $[K]\ [T] = [Q]$.

[13 marks]

d. Calculate the temperature at the interface between the two insulating materials and on the outer surface.

[4 marks]

e. Are you able to obtain better accuracy for the results in part d. above, if higher order elements are used? Explain.

[3 marks]

Continued ...

Question 2

The boundary value problem for a clamped-clamped beam can be written as:

$$\frac{d^4w}{dx^4} - p(x) = 0, \qquad 0 < x < 1$$

$$w(0) = w(1) = \frac{dw}{dx}(0) = \frac{dw}{dx}(1) = 0$$

When a uniformly distributed load is applied, i.e., $p(x) = p_0$, calculate the approximate beam deflection $\tilde{w}(x)$ (in terms of x and p_0), using:

a. Ritz method. Also, show (in detail) that the weak form is given as:

$$B(w, v) - l(v) = 0$$

$$B(w, v) = -\int_0^1 \left(\frac{d^3w}{dx^3}\right)\left(\frac{dv}{dx}\right) dx$$

$$l(v) = \int_0^1 vp(x)dx$$

[18 marks]

b. Galerkin method

[7 marks]

Assume the approximate deflection as $\tilde{w}(x) = c\emptyset(x) = cx^2(1-x)^2$.

Continued ...

Question 3

Use the minimum number of beam finite elements to analyze the beam shown in **Figure Q3**. In particular:

a. Give the global finite element equation for the system in the form of $[K]\ [U] = [F]$.

[15 marks]

b. Solve for all the unknown global displacements, both vertical and angular which arise in the assembled finite element equation of part a. above.

[10 marks]

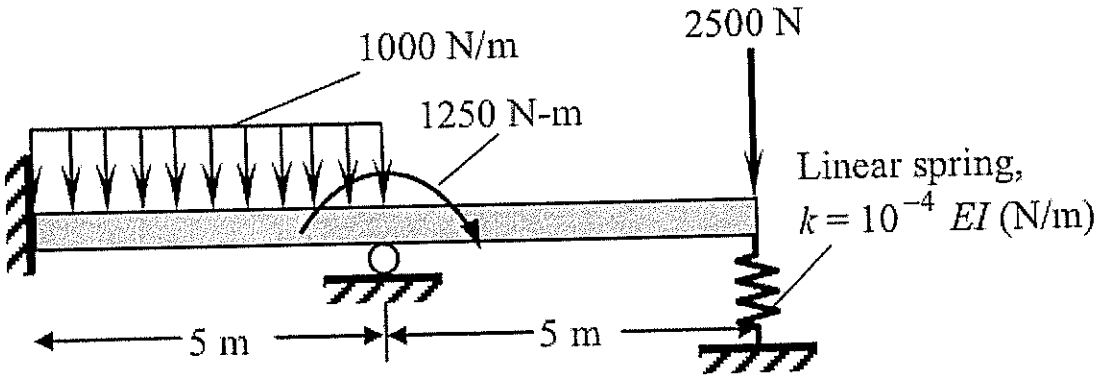

Figure Q3

Continued ...

Question 4

A two dimensional heat transfer finite element model is shown in **Figure Q4**. The domain is discretized by using 3 triangular elements with a total of 5 global nodes. The top surface (surface 4-5) is subjected to convection while the bottom surface (surface 1-2) is fixed at temperature of T_0 = 50 ^{0}C. The sides (Surfaces 1-4 and 2-5) are insulated. The ambient temperature, T_{amb} is 20 ^{0}C, the convection coefficient, h is 30 W/m^2 and the thermal conductivity, k is given as 100 W/m°C. Take a as 0.1m and thickness as 1 unit. By using the given global and local node numberings, do the followings:

a. Provide the global finite element equation for the system in the form of $[K]$ $[T]$ = $[Q]$.

[16 marks]

b. Solve for the unknown temperatures at global nodes 3, 4 and 5.

[9 marks]

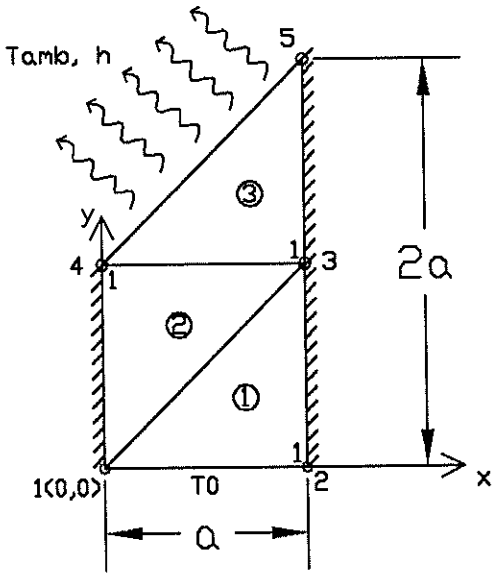

Figure Q4

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